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A single-year comparison of two methods of censusing breeding Red Knot and Sanderling in High Arctic Greenland

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A uniquely intense field effort at Zackenberg, NE Greenland, in June–July 2003 made it possible, for the first time, to compare two methods of measuring breeding densities of two notoriously difficult-to-census High Arctic breeding shorebirds (Red Knot *Calidris canutus* and Sanderling *Calidris alba*): (1) mapping of displays and other activities of birds in a rapid assessment early in the season, and (2) systematic 'roping' of potential breeding areas to disturb and then find incubating birds on, or very close to, their nests. The latter method is particularly relevant to species that rely on crypsis to avoid nest detection. During 16 and 19 June an experienced observer, in a standardized way, mapped all visual observations of Red Knot and Sanderling over a 4.0 km^2 study area, which consisted mainly of low-angle mountain slopes between altitudes of 100 and 400 m. The observations were interpreted to represent 8–9 'pairs' of Red Knot and 13–17 'pairs' of Sanderling. Observations nearby allowed for a few additional pairs of Red Knot. Between 17 June and 5 July a team of five observers systematically roped the same study area and found two Red Knot nests and 15 Sanderling nests. Most of the study area remained under daily scrutiny until 19 July, and during these visits we encountered two more families of Red Knots and seven more Sanderling families. Thus, the roping effort yielded a few more Sanderling 'pairs' than expected from the early-season survey, but fewer Red Knot. This may imply that either: (1) the early-season rapid assessment particularly overestimated the knot population, and/or (2) relative to Sanderlings, knot nests were heavily depredated before roping, and/or (3) incubating birds escaped notice during roping, and/or (4) some of the local Red Knots may not have started a breeding attempt at all. Further work with radio-tagged individuals is necessary to establish whether we need to invoke non-breeding as a cause of the discrepancy.

INTRODUCTION

The breeding population sizes of High Arctic shorebirds, just like their more southerly breeding counterparts, are not easy to establish (e.g. Meltofte 2001a, Thorup 2005). The reliance of shorebirds on effective crypsis of both eggs and incubating birds, their widely dispersed nest sites, their variable and sometimes difficult to define territorial systems with extensive and wide-ranging aerial displays, the tendency in some species to join alarm-calling birds from quite some distance and the possibility that some of the individuals that establish themselves on the breeding grounds in early spring do not actually produce a clutch, make the measurement of densities of tundra-breeding shorebirds a potentially highly statistically-unrepeatable activity. Meltofte (2001a) examined these issues based on extensive experience in High Arctic Greenland and recommended the mapping of pairs and territorial individuals as early as possible in the season during pair-formation, territory-establishment and egg-laying. This is the only time when all birds using a certain breeding area are present, and when they are easiest to record.

In this contribution we document the results of a labour-intensive study of nest densities in Red Knot *Calidris canutus* and Sanderling *Calidris alba* in a long-term monitoring area in NE Greenland (Meltofte 2004, Meltofte & Berg 2004) where standard observations on their yearly densities had been carried out using simple methods since 1996 (Meltofte 2006). The Red Knot is a particularly enigmatic High Arctic

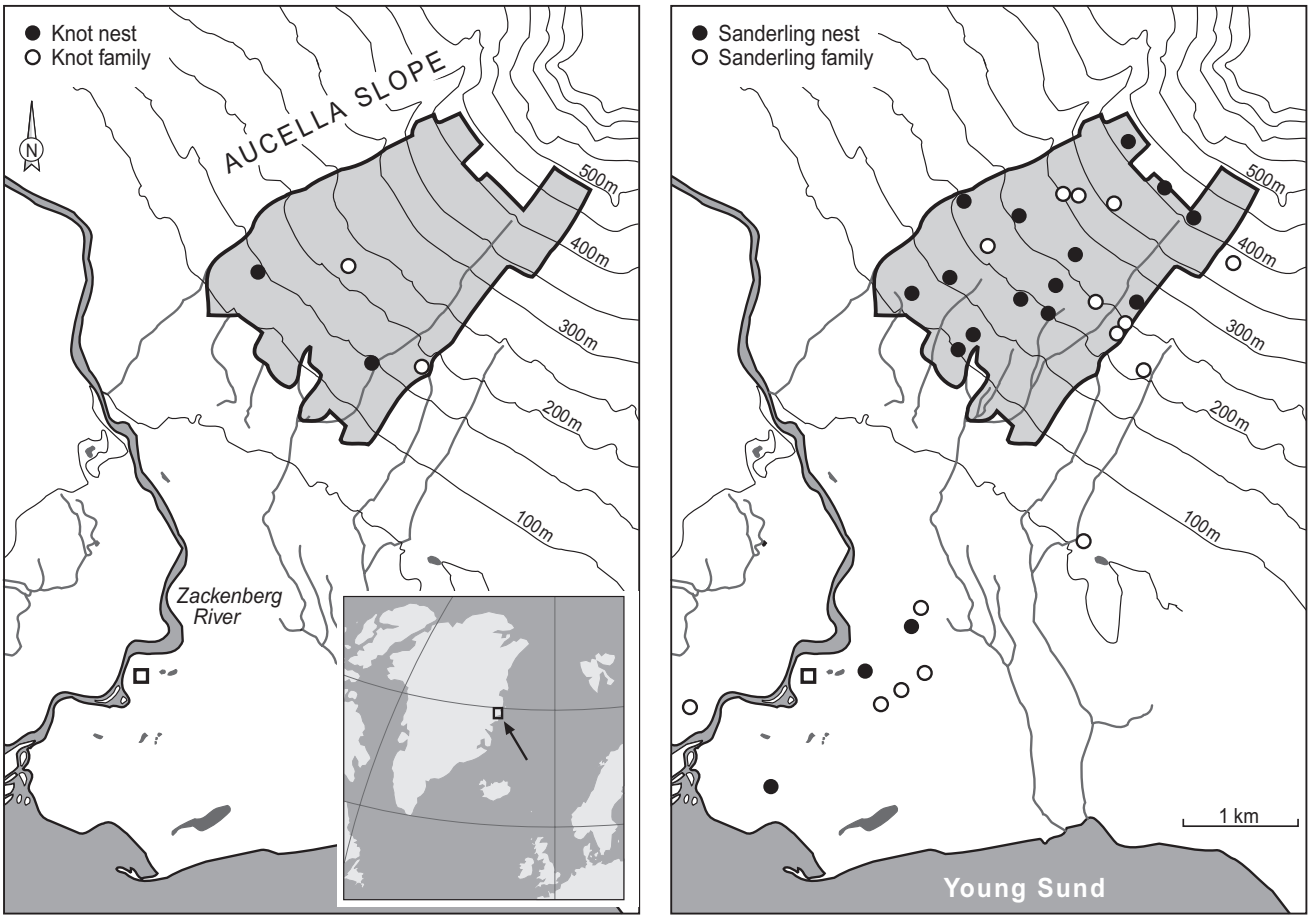

Fig. 1. Locations of nests (closed dots) and first encounters of families with chicks (open dots) of Red Knots (left-hand panel, Fig. 1a) and Sanderlings (right-hand panel, Fig. 1b) in the Zackenberg valley, NE Greenland, with the core study area covered by roping indicated with grey shading. The square shows the position of the research station.

breeding shorebird species because of its confusing territorial system and complete reliance on crypsis at the nest (see also Whitfield *et al.* 1996). Sanderlings, on the other hand, often rely less on crypsis, but may leave their nests before the approach of observers and thus escape detection. Our simple aim here is to present the results of standardized visual observations and compare them with the results of 'combing' part of the monitoring area by a team of five observers employing ropes to disturb incubating birds on their nests, and subsequent scrutiny of the study area for broods. We emphasise that, despite our best efforts, the findings are necessarily limited to observations of anonymous birds and to a single season. It is up to future workers to integrate these results into a more robust methodological assessment.

STUDY SITE AND METHODS

The study was carried out at Zackenberg (74°30'N, 20°30' W) in NE Greenland, in part of the 19.3 km^2 bird monitoring area established in 1995. We selected a core study area of 4.0 km² of low-angle (*c.*12°–13.5°) south-west facing slopes of Aucellabjerg, mainly between altitudes 100 and 400 m (Fig. 1). Here Red Knots had most consistently shown up in previous years; two nests were found in 1998 and one in 1999. To avoid edge effects as much as possible, the study area had a squared outline.

Every year, as part of the long-term monitoring programme, BioBasis, the core study area as well as surrounding land is covered by a 'rapid assessment' of the size of the breeding wader populations. This is carried out when most species have initiated egg-laying or have started incubation, i.e. from 12 June onwards (see Meltofte & Berg 2004). Each year, following the rapid assessment, the observer normally works in the census area during the rest of the breeding season, trying to confirm as many territories as possible by the finding of nests or small young or by repeated records of alarm-calling pairs or individuals (see examples of data and discussion in Meltofte 2001a). In 2003, the total study area was covered by a rapid assessment over two days, 16 and 19 June, by an experienced observer (HM) mapping and evaluating all records of waders according to standardised monitoring guidelines (Meltofte & Berg 2004). Records of pairs, as well as single singing and otherwise vocal (alarm-calling) individuals, were taken as representing breeding pairs or territories. The nesting area of birds in aerial display was usually established by following them until they landed. Other records (of single, non-vocal individuals) were added as representing possible territories.

In 2003, a team of five experienced observers worked in the study area for 6–8 h almost every day from 17 June to 19 July (see also Reneerkens *et al.* 2005). We intensively combed the 4 km^2 core study area. All snow-free parts of the area were visited between 17 June and 5 July, after which no more nests are normally initiated (Meltofte 1985). The method involved dragging a rope between two people over the tundra, thus disturbing birds sitting on their nest. We used

0.5-cm thick nylon ropes that were carried between two persons: a 20 m blue rope and a 50 m orange rope. Usually a third observer followed the centre of the 50-m rope and sometimes we had three people walking the two ropes simultaneously (the middle person holding a rope in each hand). We adjusted the length of rope used to local terrain conditions and assume that both ropes had the same effectiveness. Using GPS we systematically covered all available snow-free ground in the study area, extending coverage as the snow receded. Roping works best for species that completely rely on the crypsis of their dorsal plumage when sitting on the nest. Red Knots are such a species, and in our experience in north-central Taymyr, Siberia (Tulp *et al*. 1998), they only flush from the nest just before or upon the passage of a rope (or a walking observer) closely overhead. In such cases, the bird will leave the nest and immediately try to distract the intruders' attention by noisy and elaborate distraction display (see Harrington 2001 for description). This is precisely what happened at seven nests found at Zackenberg from 1998 to 2003, including the two nests located by roping in 2003. It seems likely that sometimes these methods will not succeed in flushing a knot from its nest. Compensation for this and any lack of completeness of roping coverage can, to some extent, be made later by searching for family parties.

Sanderlings more often flush just before observers and rope reach the nest and they then show elaborate distraction displays. However, many Sanderlings found in the study area in 2003 left the nest when the rope and observers were still more than 10 m away and were located by sight or noticed by soft alarm calls. Sanderling nests are thus predicted to be under-recorded by the roping method. On the other hand, the 'double-clutching' breeding system of some Sanderling populations may mean that there are more nests than there are pairs in an area, so nests found by roping may approximate to the number of pairs. In our experience, roping does not work very well for species that breed in marshes, such as Dunlin *Calidris alpina*, or for those that advertise their territories from a distance such as Ruddy Turnstone *Arenaria interpres* and Common Ringed Plover *Charadrius hiaticula*. Nests of these species are most readily located by seeing birds flush when disturbed or following birds back to their nests from a distance after a disturbance (Meltofte & Berg 2003).

RESULTS

During the rapid assessment on 16 and 19 June, two pairs of Red Knots, three singing individuals, two alarm-calling individuals, one silently feeding individual and two individuals involved in a flight pursuit were recorded within the 4 km^2 core study area on the slope of Aucellabjerg. One of the birds in flight pursuit was singing and only two records of singing individuals did not involve birds on the ground. At two of the places where Red Knots were found, singing individuals had previously been recorded on 3 and 15 June, respectively. Evaluation of these recorded suggested that 8–9 pairs of Red Knots were present in the study area. One further pair was recorded a few hundred metres east of the core area on 6 June and was considered to represent a pair outside the study area. In addition, four pairs/singing individuals, recorded in the marshes below the selected area, may have belonged to the population on the slopes (which on the Aucellabjerg alone extend for about five times the study area). On the basis of the rapid assessment data and other observations, we expected to find about ten nests. However, the roping of the 4 km^2 area of slopes yielded only two nests, both of which were depredated before hatching (Fig. 1a). During further observations until 19 July, a further two broods were found in the study area. One brood of four chicks was only one day old when found on 4 July just next to a deep ravine separating the study area from other parts of the parts of the south-west-facing slope of Aucellabjerg to the east. The other brood found on 16 July consisted of only a single *c.*11 day-old chick. It might have wandered in from a neighbouring area, but for the purposes of this analysis, we assume it did not.

The evaluation of the records for Sanderlings during the rapid assessment yielded a total of 13–17 pairs or 'territories' within the core area and one very close nearby (Fig. 1b). Roping and the following search for nests and broods yielded a total of 15 nests and seven additional broods; 22 broods or nests altogether. These figures may be broken down into the two parts of the slopes that were the subject of the rapid assessment on 16 and 19 June, respectively. In the area covered on 16 June, eight nests and broods were found compared with 7–9 'territories' during the rapid assessment, while in the area covered on 19 June, 14 nests and broods were found compared with only 6–8 'territories' during the rapid assessment. These comparisons are somewhat complicated by the fact that some Sanderlings may produce double-clutches where a female lays two clutches in rapid succession and leaves the care of the first to a male, usually the father (see Parmelee & Payne 1973, Pienkowski & Green 1976). Indeed, of 20 nests found in 2003 (within and outside the core study area), two different attending birds were either caught or seen at 10 nests, while only one attendant was encountered at repeated catches or visits at four nests. The status of six nests was uncertain. These observations accord with earlier records indicating that a mixed strategy occurs at Zackeneurg (Meltofte 2001b, 2003 and unpubl. info.).

DISCUSSION

The finding of two Red Knot and 15 Sanderling nests in the 4-km^2 study area for comparison with rapid assessment data is not as trivial as it may first appear. Roping 4 km^2 of sloping tundra is a gargantuan task for a small team. According to the literature, it is the largest area of Red Knot breeding habitat covered to date by the roping method (cf. Tulp *et al.* 1998). More importantly, our study provides the intensive survey data for comparison with the standardized and much more widely used rapid assessment method.

For the interpretation of the results of the rapid assessment on 16 and 19 June it is important to have an idea about general breeding phenology. Using egg-flotation and chick-weights, the laying date of the first egg in clutches of Red Knots was estimated (see Meltofte & Berg 2004 for details). Including three broods found outside the selected area, the seven clutches in 2003 were initiated around 4, 7, 9, 12, 18, 19 and 28 June, respectively. This is well within the range found for Red Knot in High Arctic Greenland (Meltofte 1985). At Zackenberg, during 1995–2003 a total of 27 clutches were initiated as follows: two during 1–5 June, nine 6–10 June, four 11–15 June, seven 16–20 June, two 21–25 June and three during 26–30 June. Most likely, all broods initiated after 20 June and even some of those after 15 June were relays after predation or other failure of the original clutch (cf. Meltofte 1985, 2001a). Similarly, 123 Sanderling clutches from 1995–2003 were initiated as follows: one during 1–5 June, eleven 6–10 June, thirty-one 11–15 June,

thirty-seven 16–20 June, twenty-six 21–25 June, twelve 26–30 June, three 1–5 July and two 6–10 July. In our study year 2003, the range of first egg dates for 36 clutches (this includes nest findings as well broods with chicks aged on the basis of body size; see Meltofte & Berg 2004) was 5–28 June. The median was 13 June and hence, somewhat earlier than in most other years (Meltofte 2004).

For Sanderling, the number of 'pairs' discovered during the rapid assessment (13–17) was similar to the number found by the roping method (15), but this was supplemented with subsequent new discoveries of hatched broods (plus 7). Given that there is some evidence for double-clutching (see below), yielding extra nests, the numbers are encouragingly similar. However, if some nests were missed because there were destroyed by predation before discovery (see also below), we must conclude that the rapid assessment in 2003 yielded an underestimate of the number of breeding attempts by Sanderlings.

For Red Knot, the discrepancy between 'pairs' discovered during the rapid assessment and nests found was in the reverse direction: at least eight pairs/'territories' of Red Knots were mapped during the rapid assessment, but only four nests and broods were encountered during roping and the following search. The latter may have several complementary explanations:

(1) The rapid assessment may have overestimated numbers, since Red Knot roam widely during territory establishment, egg laying and incubation (the 'off-duty' mate). This would more likely have been the case with the pairs and singing individuals that were recorded in the marshes below the slopes, but probably less so in the study area on the slopes. On the contrary, it could be argued that some of the local 'off-duty mates' might be roaming outside the census area, perhaps feeding in the lowland marshes, and would have been missed altogether. Daily, during all of June and most of July we recorded singing or otherwise aerially performing of Red Knots above the prime-breeding habitat on the slopes. Although surveys should preferably be conducted during pair formation and territory establishment, we determined that the rapid assessment on 16 and 19 June took place when most of the birds had eggs. Thus, most of the rapid assessment records could be expected to involve only one of the mates. This was found to be the case.

(2) Some nests may have been depredated before roping. That predation took place is certain, since the two nests found in 2003 were depredated before hatching. Furthermore, the two relatively late Red Knot clutches of 18 and 19 June, and the very late one of 28 June, most likely were relays. One Arctic Fox *Alopex lagopus* den near the study area held pups and two more dens in the valley were occupied and also held pups. To what extent Red Knot and Sanderling nests are vulnerable to predation is not well established. At Zackenberg during 1996–2003, predation ended an average of about half the Sanderling nests before hatch. We do not have sufficient data for Red Knot, but for the equal sized Ruddy Turnstone, predation averaged about 60% during 1996–2004 (Thorup & Meltofte 2005).

(3) Some incubating birds may have escaped notice during roping, either from incomplete coverage (a problem we tried very hard to avoid) or from the bird remaining tight on the nest during the passage of the rope. This possibility was indicated by the appearance of one or two broods (one could have walked in from a neighbouring area) in places that were roped during the period when the eggs of these broods were incubated. We would have expected this effect to be larger in Sanderlings than in Red Knots because of the readiness of Sanderlings to leave their nests well in advance of the rope.

(4) Some local birds may have been non-breeders.

The latter possibility can be illustrated by findings near Alert, Ellesmere Island, Canada. Reneerkens *et al*. (2002) caught an adult female Red Knot and an adult male on 13 and 18 June 1999, respectively. None of the birds had developed a brood patch. This suggests that at that stage these individuals still lacked a clutch, in contrast to the majority of Red Knots near Alert in mid June (Reneerkens *et al*. 2002). Given the late date, we consider it unlikely that these two individuals would have started a clutch after their day of capture. The colour-marked female was seen near Alert on seven other occasions up to 5 July, and the male was resighted on 27 June, suggesting that both non-breeders stayed on the breeding grounds for quite some time (R.I.G. Morrison unpubl. data).

Another indication for the presence of non-breeding shorebirds in the High Arctic comes from Danmarkshavn 300 km north of Zackenberg, where Meltofte (1979) found up to 20 Ruddy Turnstones in a communal feeding area during two weeks in the middle of June 1975, i.e. after the pre-breeding flocks had broken up and most breeders were either laying eggs or incubating. Ten birds caught for ringing and one male found dead had no brood patches, and their weights were significantly lower than in breeders. The dead male had at least 30% smaller testes than breeding males from the same period, and hence, these birds most likely were non-breeders.

The estimated density of Red Knots based on visual observations for the core study area (2.0–2.3 pairs per km^2) was almost double that of the total Zackenberg census area (1.2–1.3 pairs per km^2), but well within the range found in other census areas with relatively dense Red Knot populations (1.3–12.7 pairs per km^2; Nettleship 1974; Whitfield *et al*. 1996). The density in the total census area was within the range for other large census areas with breeding Red Knot in High Arctic Greenland and Ellesmere Island (0.1–1.7 pairs per km^2; Mortensen 2000). The ratio of confirmed breeders in relation to the estimated population was very much the same as found in the most intensively covered part of the census area, the area west of Zackenbergelven (3.47 km^2; see Meltofte & Berg 2004) during 1996–2003. Here, between 1 and 4–5 territories were estimated per year giving an accumulated total of 17–24 territories, of which 6–8 were confirmed by observations of chicks (no roping or other specific searches for Red Knot nests were performed here).

Meltofte (2001a) presented data from the first years of monitoring at Zackenberg that showed decreasing numbers of shorebirds recorded in the breeding habitats following egg-laying around mid June. After that time, many birds behaved very inconspicuously. There was a further decrease in the number of birds recorded around 1 July with the departure of failed breeders, then another drop when mates not caring for the chicks (mainly females) left early and finally the successful breeders that had cared for the chicks (mainly males). This

led Meltofte (2001a) to suggest that censuses of Arctic shorebirds should take place immediately after dispersal on the breeding territories, i.e. during territory establishment and egg-laying. This would have the consequence that non-breeders that stay in the breeding habitats either as prospectors or just refrain from breeding are included in the census results. We believe that this is actually an advantage if the intention is to establish a basic population figure, i.e. the numbers of individuals that compete for space, resources and mates on the breeding grounds. The proportion of the birds that actually breeds must then be established by more thorough study. To fully demonstrate the presence of non-breeding individuals, it is necessary to radio mark a sample of post-arrival birds and then follow them to determine their status.

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"Roping" at Zackenberg